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SHORT COMMENTARY

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An Overview of Radiation-Based Gold Nanoparticle Synthesis

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Abstract

Because the optical properties of gold nanoparticles are programmable as a function of size and shape, they have spawned an emergent platform of nanogold-based devices for a variety of applications. The radiolytic synthesis, among the known procedures for the synthesis of gold nanoparticles, offers proper control of the nucleation process without the use of reducing agents, in a single step, combined or not with simultaneous sterilisation. This paper examines and describes the use of radiation technologies in the synthesis and preparation of gold nanoparticles, with a focus on fundamental features of synthesis and radiation sources, as well as final applications for nanogold-based systems.

Keywords

Gold Nanoparticles; Radioloytic; Bioconjugation; Nanoshells;

Introduction

Nanomaterials

Nanomaterials are a new form of material that has only recently become popular. The word refers to a material in which at least one dimension of three-dimensional space is on the nanometer scale (0.1 nm-100 nm), or is made up of the basic unit, which is roughly equivalent to the size of 10 atoms-100 atoms, packed tightly together[1,2]. Nanoparticles are a type of nanomaterial that has had the greatest time to develop and is currently the most developed technology. Nanoparticles and nanotechnology are widely employed in a variety of sectors, including medicine, biology, physics, chemistry, and others. Noble metal nanoparticles (Cu, Hg, Ag, Pt, and Au) have become increasingly popular in contrast to other metal nanoparticles.

Gold Nanoparticles

When noble metals, such as gold, are used to make nanostructured materials, they exhibit all of the aforementioned characteristics as well as others, such as minimal toxicity to biological systems and conformational flexibility. Colloidal gold has been empirically utilised for millennia in a variety of purposes. The biological capabilities of gold nanoparticles have emerged in recent decades, ranging from surface modification by bioconjugation of specific molecules to optical features tailored for diagnostic techniques based on the shape of the particles, among other things. Bulk gold nanospheres to composites of polymeric nuclei covered by gold nanoparticles can take on a variety of shapes [3-5]. A dielectric nucleus, i.e., made of silica, is coated by a layer of gold, the so-called nanoshells, in another morphology of gold nanoparticle [5]. The wavelength at which the surface plasmon resonance is activated is determined by the thickness of the metallic layer, which ranges from ultraviolet to near-infrared wavelengths, where tissue penetration is more intense. Researchers are also interested in gold nanorods because of their ease of manufacturing and huge surface area accessible to interact with light per unit of volume when compared to other conformations [6]. Gold nanocages have recently been produced as potential medication carriers. By altering the thickness and porosity of the walls, their surface plasmon resonance peaks can be adjusted to near-infrared wavelengths. Other objects, such as smaller magnetic nanoparticles for various applications, may be carried in the hollow interiors of these nanoparticles in addition to drug loading. Gold nanoparticles (AuNPs) are the most stable of them, and they've been synthesised into a variety of shapes and structures, including nanospheres, nanorods, nanocubes, nanobranches, nanobipyramids, nanoflowers, nanoshells, nanowires, and nanocages.

Methods of Synthesis: An Overview

Gold nanoparticles can be made in a variety of methods. Top-down protocols (usually physical-chemical processes used to degrade a bulk material into smaller pieces, achieving the nanometric scale) and bottom-up protocols (usually physical–chemical processes used to degrade a bulk material into smaller pieces, achieving the nanometric scale) are the most commonly used protocols (the most abundant protocols for nanomaterials, where the syntheses of nanoparticles part from smaller precursors). Physical, chemical, and biological approaches can also be distinguished. Supercritical fluid technology has made some contributions in this area, but only to a modest level. These technologies are combined to create a wide range of nanoparticle morphologies, each with its own set of attributes for a given purpose. Physical approaches are mostly based on the energy transfer that occurs in a material when it is treated with ionising or non-ionizing radiation, which can cause reduction processes that result in the nucleation of metallic particles. Photochemical reactions, ionising radiation, and microwave radiation are examples of these approaches. In nanomaterial applications, green approaches are becoming more common [7,8]. The microwave-induced plasma-in-liquid method (MWPLP) is a good example of green nanoparticle production because it does not require the use of harmful reducing agents and uses very little energy. MWPLP, like gamma or X-ray radiolysis, is based on the breaking of water molecules by microwaves, resulting in the formation of reducing agents that lead to the nucleation of metallic particles. The creation of gold nanoparticles can also be done with laser sources.

Biomedical Applications

Due to the various optical and electrical properties achieved at the nanoscale, as opposed to the qualities of gold in its macroscopic form, gold nanoparticles have gotten a lot of interest since the emergence of nanotechnology. The combination of these features enables them to be used in the diagnosis and treatment of a wide range of disorders.

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Table 1: Applications of Gold Nanoparticles

Method of Synthesis	Applications
Citrate-stabilized AuNP followed by grafting of polymers onto the NP	Photothermal therapy and chemotherapy [b]
Citrate reduction of chloroauric acid	Molecular biosensor techniques for the diagnosis of cancer [a]
Gold nanorods prepared by the seed-mediated method and encapsulated by silica and other compounds	Simultaneous multimodal tumor detection and photodynamic therapy [c]
Alpha-tocopheryl succinate conjugated multifunctional dendrimer-entrapped AuNP using ice-cold $NaBH_4$ solution	Platform for targeted cancer imaging and therapy [d]

Gold nanoparticles, because of their high compatibility with the human biology, low toxicity and tunable stability, compact dimensions, and capacity to interact with a range of chemicals, they are suited for controlled drug delivery, cancer treatment, biomedical imaging, diagnosis, and many other applications [8].

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